

LON-CAPA Project Overview and Recent Developments

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LON-CAPA 9th Annual Conference and Workshop

University of Illinois

May 2007

LON-CAPA Overview

- LON-CAPA is
 - free
 - open-source
 - a learning content management system
 - an assessment system

Free and Open-Source

- Free:
 - “Free beer”: no licensing fees
 - “Free speech”: source code, Bugzilla, mailing lists, reseach results, all out in the open
- Open-source:
you can read, modify, improve, adapt, etc, the original code of the system
- BUT: derivative must be distributed under same license, i.e., GNU General Public License

```
while ($line=<IN>) {  
    chomp($line);  
    $line=~s/\s+$//s;  
    $line=~s/\"//g;  
    $line=~tr/A-Z/a-z/;  
    @entries=split(/\/,$line);  
    $username=$entries[4];  
    —
```

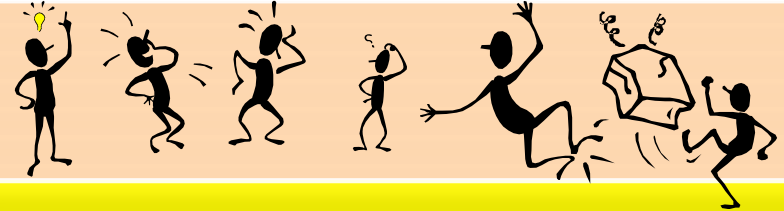
LON-CAPA Architecture



Course Management

Campus A

Resource Assembly



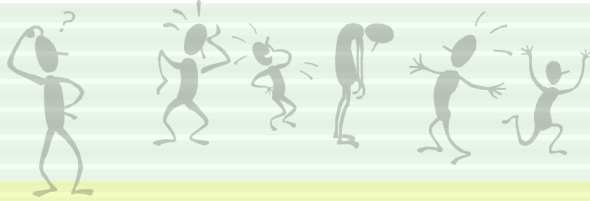
Course Management

Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

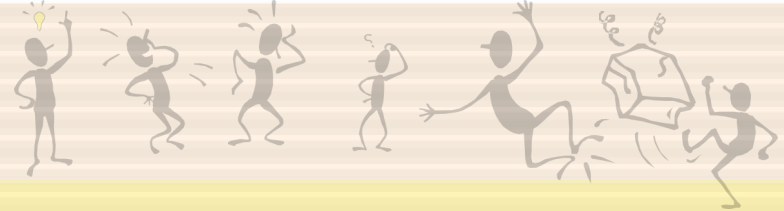
LON-CAPA Architecture



Course Management

Campus A

Resource Assembly



Course Management

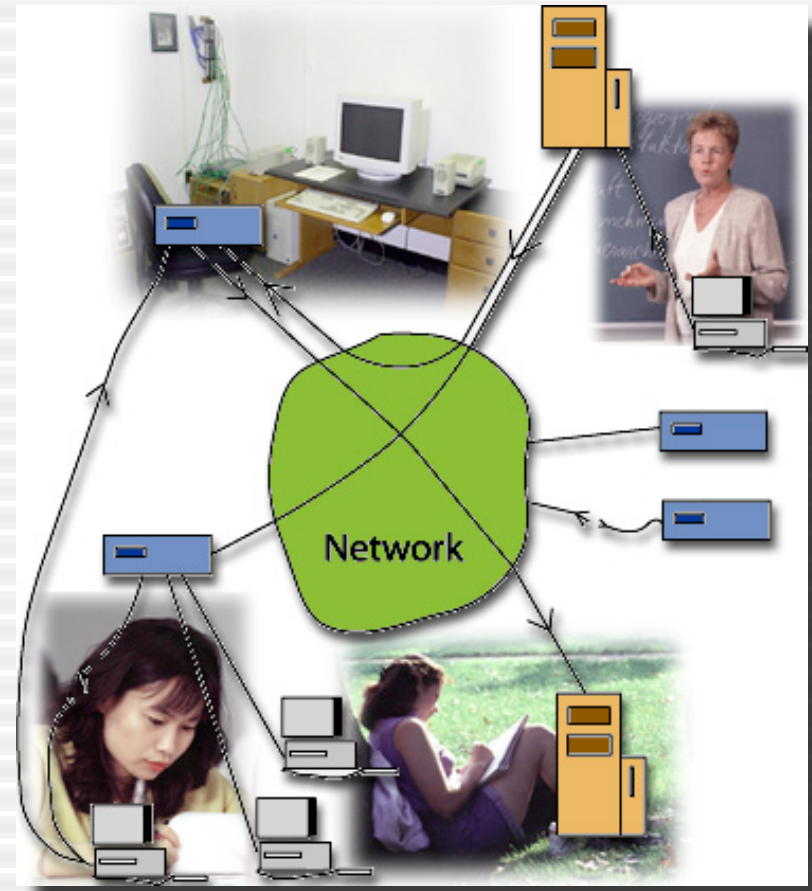
Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

Shared Resource Library

- LON-CAPA currently links 106 institutions in eight countries



Shared Resource Library

- The distributed network looks like one big file system
- You can see each institution, the authors at that institution, and their resources

▶	Domain - sc (University of South Carolina)
▶	Domain - sfu (Simon Fraser University)
▶	batchelo
▶	chem281
▶	exafs
▶	hanlan
▶	mxchen
▶	slavieri
▶	vjungic
▶	Domain - sunysb (SUNY Stony Brook)
▶	Domain - tmcc (Truckee Meadows Community College)
▶	jensen
▶	mbauer
▶	souza
▶	Greenberg
	default.sequence (metadata)
▶	samples
▶	testuser1
▶	Domain - ucf (University of Central Florida)

Shared Resource Library

- Resources may be web pages ...

EXAMPLE

Example: Looping

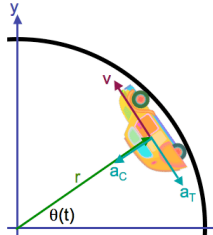
A toy car can go through a looping if it is fast enough. What are the forces that act on it? How fast does it have to be?

The motion is obviously circular, but non-uniform: the car will slow down on the way up, and speed up on the way down. With r being the radius of the looping, the x -axis horizontal, the y -axis pointing up, the origin being in the center of the looping, and $\theta(t)$ being the angle, the position of the car is given by

$$\vec{r}(\theta) = \begin{pmatrix} r \cos(\theta(t)) \\ r \sin(\theta(t)) \end{pmatrix}$$

as long as it does not fall off the track.

The figure below illustrates the setup:



EXAMPLE

Focal Length

The following pictures are taken from the same vantage point with three different zoom lenses:

- 17mm-35mm wideangle zoom
- 24mm-70mm normal zoom
- 70mm-300mm tele zoom

using a digital camera with an image sensor of 24mm x 36mm (standard so-called 35mm image format).

17mm extreme wide angle



35mm mild wide angle



24mm wide angle



48mm normal



Impedance

The addition of the three currents (through the resistor, the inductance, and the capacitance), each of which is 90° out of phase with each other, in quadrature yields:

$$\begin{aligned} V &= \sqrt{V_R^2 + (V_C - V_L)^2} \\ &= \sqrt{(IR)^2 + (IX_C - IX_L)^2} \\ &= I \sqrt{R^2 + (X_C - X_L)^2} \\ &= IZ \end{aligned}$$

where I is the current, X_C and X_L are the [capacitive](#) and [inductive](#) reactances, respectively, and Z is the [impedance](#). Putting in the values of the reactances, we obtain for Z :

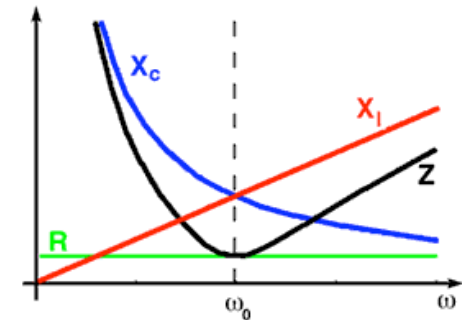
$$\begin{aligned} Z &= \frac{V}{I} = \sqrt{R^2 + (X_C - X_L)^2} \\ &= \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2} \\ &= \sqrt{R^2 + \left(\frac{1}{2\pi f C} - 2\pi f L\right)^2} \end{aligned}$$

and has its minimum of $Z = R$ when

$$\omega_0 = (LC)^{-1/2},$$

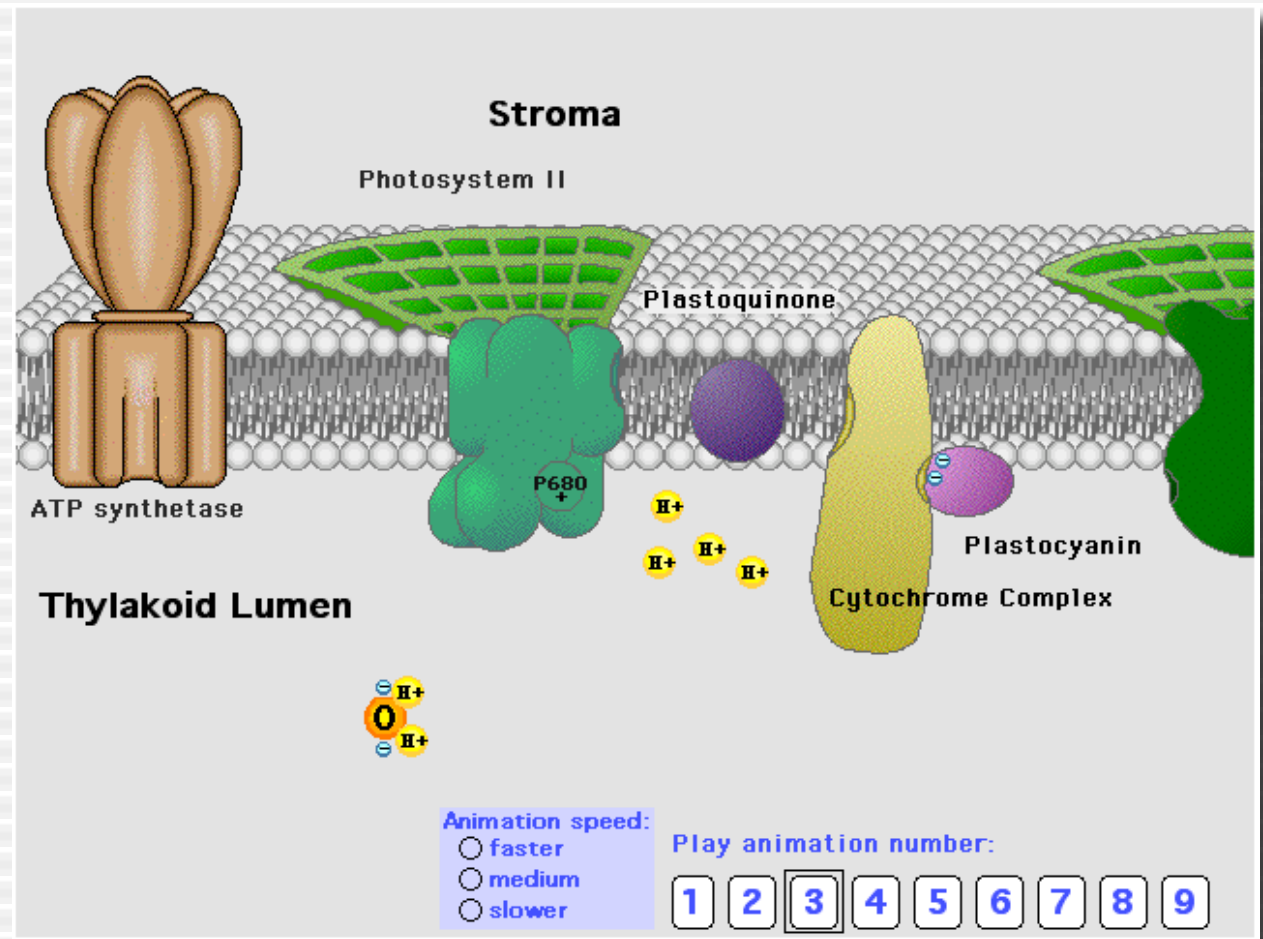
pure LC circuit. This is the [resonance frequency](#) of the RLC circuit. The impedance and of the reactances is shown in the figure.

have to be added in a special way. They end up as a single quantity Z , the [impedance](#).



Shared Resource Library

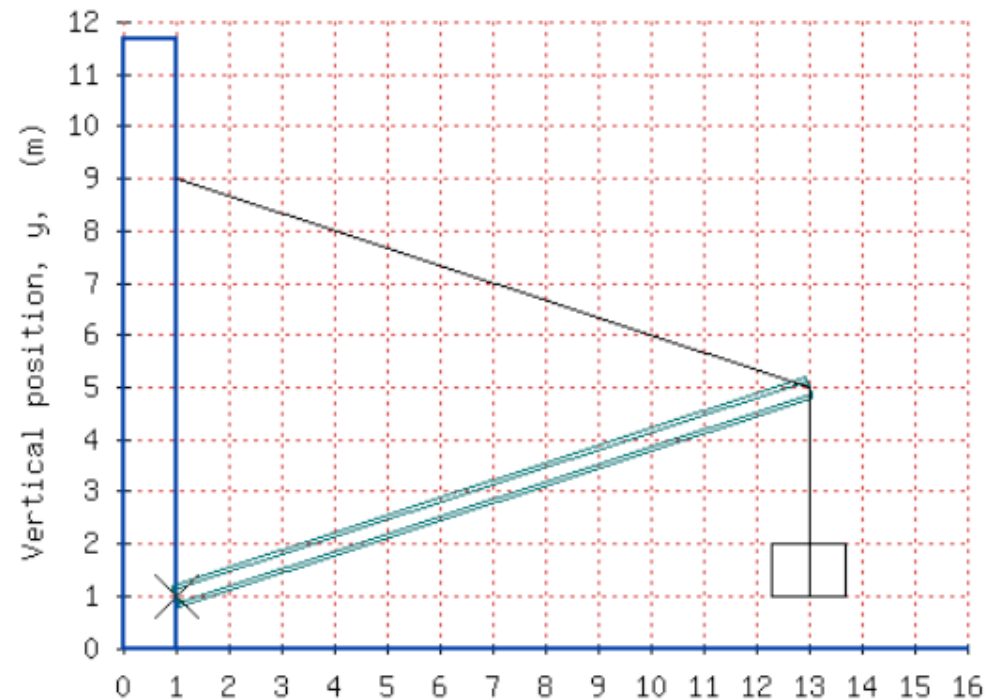
- ... or simulations and animations ...



Shared Resource Library

- ... or this kind of randomizing online problems

A crate with a mass of 155.5 kg is suspended from the end of a uniform boom with mass of 89.5 kg. The upper end of the boom is supported by a cable attached to the wall and the lower end by a pivot (marked X) on the same wall. Calculate the tension in the cable.



Shared Resource Library

- ...special emphasis on math

What is the derivative of

$$\begin{pmatrix} 4t^3 \\ 8t^8 \end{pmatrix}$$

with respect to t ?

You need to multiply with the original exponent.

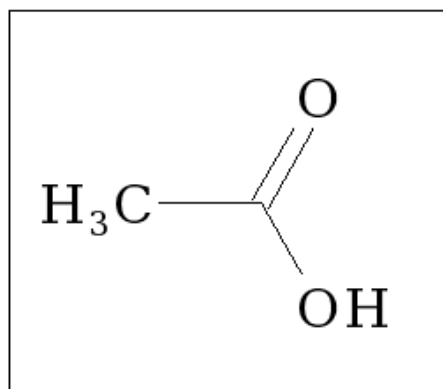
[Submit Answer](#)

Incorrect. Tries 1

Shared Resource Library

- ... chemistry ...

The image below is $C_2H_4O_2$



Draw acetic acid.

Draw Molecule

Submit Answer Tries 0/99

[Post Discussion](#)

Untitled

Select substituent ▾

☺	CLR	DEL	D-R	+/-	UDO	JME	
☞	—	=	≡	~	△	□	◡
C							
N							
O							
S							
F							
Cl							
Br							
I							
P							
X							

The JME Editor interface shows a partial drawing of acetic acid. The central carbon atom is double-bonded to an oxygen atom (top) and single-bonded to a hydroxyl group (OH, bottom right). A methyl group (H_3C) is attached to the left of the central carbon.

JME Editor courtesy of Peter Ertl, Novartis

Insert Answer

Close Help

Shared Resource Library

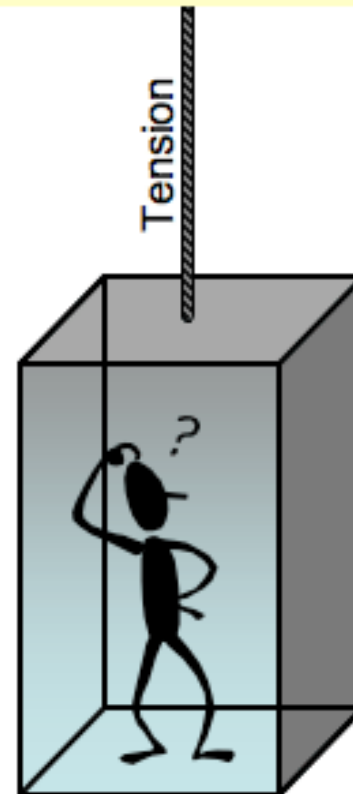
- ... physical units ...

Elevator Problem

Due never

An elevator (cabin mass 500 kg) is designed for a maximum load of 2600 kg, and to reach a velocity of 3 m/s in 5 s. For this scenario, what is the tension the elevator rope has to withstand?

[Submit Answer](#) Tries 0/99



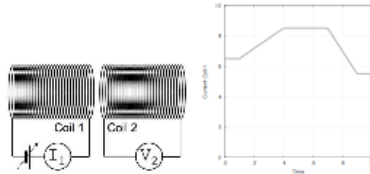
Shared Resource Library

• Dynamic Graphing

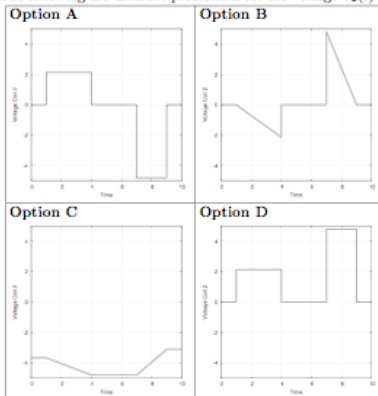
Gerd Kortemeyer

1

Two short coils are located close to each other as shown below. The current $I_1(t)$ through Coil 1 is variable and shown as a function of time in the plot below.



The following are different predictions for the voltage $V_2(t)$ induced in Coil 2.



Which of these options could be the correct measurement of $V_2(t)$?

- A. Option A
- B. Option B
- C. Option C
- D. Option D

Which one of the following actions would result in a higher magnitude of the peak voltage across the Coil 2?

- A. Placing the whole apparatus into a medium with lower permeability.
- B. Increasing the current through Coil 1 by a constant positive offset ΔI , i.e., $I_1'(t) = I_1(t) + \Delta I$.
- C. Decreasing the number of turns of Coil 1.
- D. Changing the current through Coil 1 more rapidly.
- E. Decreasing the number of turns of Coil 2.

If Coil 1 has 180 turns, and Coil 2 has 380 turns, and if a current of $I_1 = 3A$ through Coil 1 results in an average flux of $\Phi_2 = 0.08Tm^2$ inside Coil 2, what is the mutual inductance?

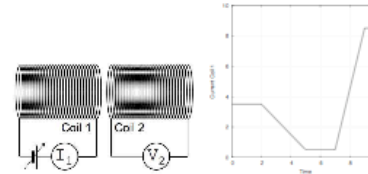
Now the coils are moved closer together, so that the new mutual inductance is 68 H. What is the magnitude of the induced voltage V_2 while I_1 is at a constant 3A?

Using the same setup with a mutual inductance of 68 H, what is the magnitude of the induced voltage V_2 if I_1 increases with 5A/s?

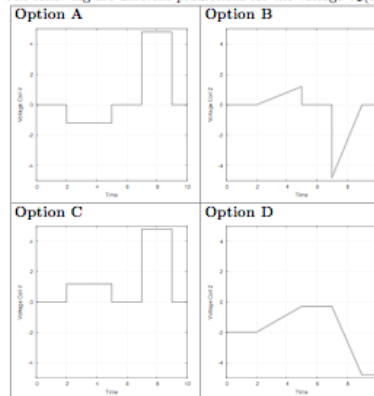
Gerd Kortemeyer

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Which one of the following actions would result in a higher magnitude of the peak voltage across the Coil 2?

- A. Decreasing the number of turns of Coil 1.
- B. Placing the whole apparatus into a medium with lower permeability.
- C. Decreasing the number of turns of Coil 2.
- D. Increasing the current through Coil 1 by a constant positive offset ΔI , i.e., $I_1'(t) = I_1(t) + \Delta I$.
- E. Changing the current through Coil 1 more rapidly.

If Coil 1 has 190 turns, and Coil 2 has 370 turns, and if a current of $I_1 = 3A$ through Coil 1 results in an average flux of $\Phi_2 = 0.07Tm^2$ inside Coil 2, what is the mutual inductance?

Now the coils are moved closer together, so that the new mutual inductance is 50 H. What is the magnitude of the induced voltage V_2 while I_1 is at a constant 3A?

Using the same setup with a mutual inductance of 50 H, what is the magnitude of the induced voltage V_2 if I_1 increases with 2A/s?

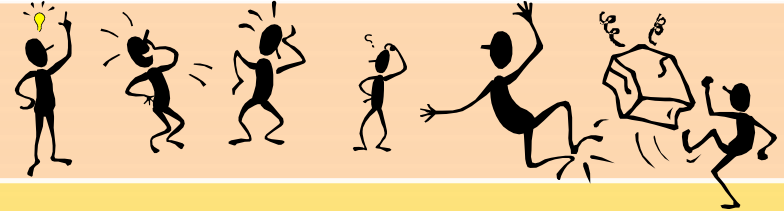
LON-CAPA Architecture



Course Management

Campus A

Resource Assembly



Course Management

Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

Resource Assembly

- Shopping Cart

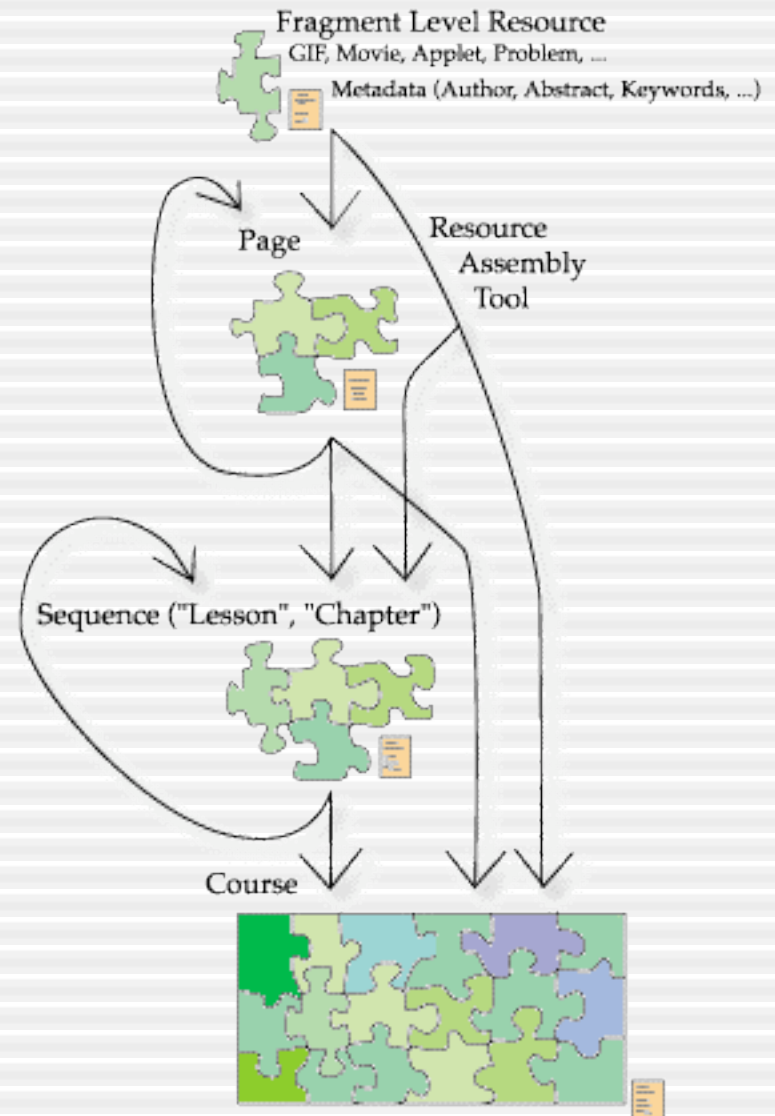


“Supermarket”

▶	Domain - sc (University of South Carolina)
▶	Domain - sfu (Simon Fraser University)
▶	batchelo
▶	chem281
▶	exafs
▶	hanlan
▶	mxchen
▶	slavieri
▶	vjungic
▶	Domain - sunysb (SUNY Stony Brook)
▶	Domain - tmcc (Truckee Meadows Community College)
▶	jensen
▶	mbauer
▶	souza
▶	Greenberg
	default.sequence (metadata)
▶	samples
▶	testuser1
▶	Domain - ucf (University of Central Florida)

Resource Assembly

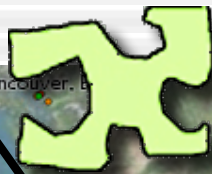
- Nested Assemblies
- No pre-defined levels of granularity („module“, „chapter“, etc)
- People can never agree what those terms mean
- Re-use possible on any level



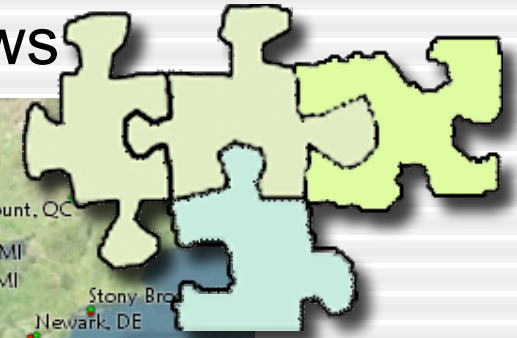
Resource Assembly



Writes module about energy conservation



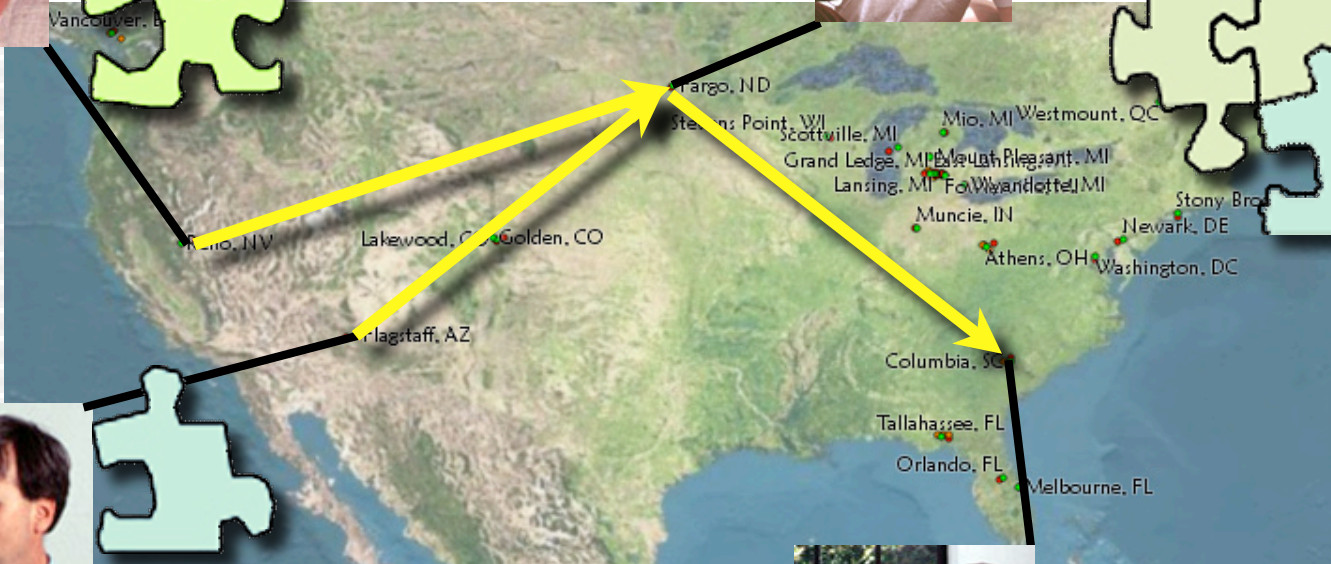
Compiles modules about conservation laws



Writes module about momentum conservation



Uses whole assembly in his course



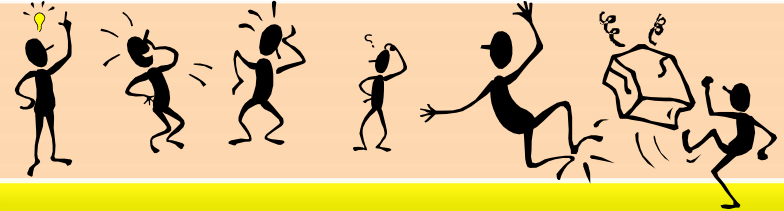
LON-CAPA Architecture



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Course Management

Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

Course Management

- Instructors can directly use the assembled material in their courses
 - navigational tools for students to access the material
 - grade book
 - communications
 - calendar/scheduling
 - access rights management
 - portfolio space

The screenshot shows a web interface for navigating course contents. At the top, there are navigation links: 'Main Menu', 'Return to Last Location', 'Navigate Contents', and 'Course Documents'. Below these is a header 'Navigate Course Contents'. A search bar contains 'Select Action' and a 'Go' button. A 'Sort by:' dropdown menu is set to 'Default'. The main content area is a list of course items:

- Syllabus
- Calendar Overview
- Electrostatics
- Electric Field
- Capacitors
 - Capacitors
 - Capacitors Materials
 - Capacitors Homework
 - Force (Answer available)
 - Spherical Capacitor (Answer available)
 - Separation (Answer available)
 - Dielectric Constant (Answer available)
 - Energy Stored (Answer available)
 - Dielectric constant 2 (Answer available)
 - Energy Density (Answer available)
 - Capacitance (Answer available)
 - Capacitance 2 (Answer available)

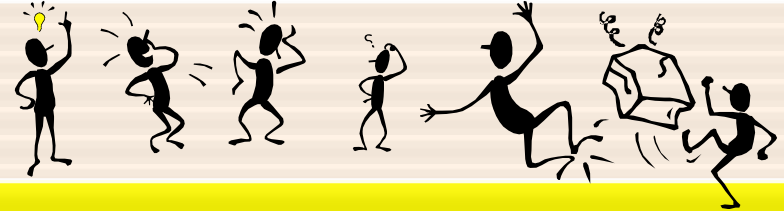
Dynamic Metadata



Course Management

Campus A

Resource Assembly

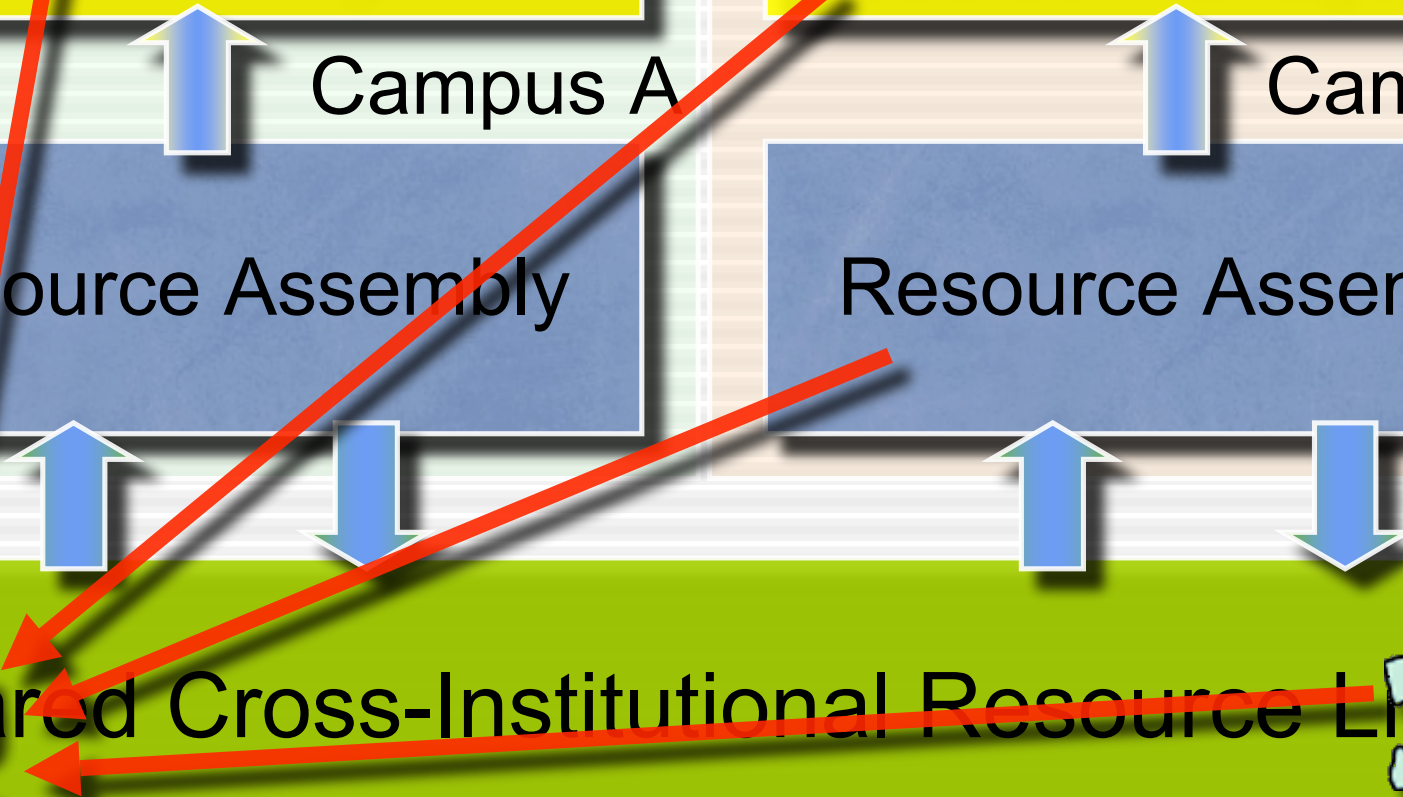


Course Management

Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

A green bar containing the text 'Shared Cross-Institutional Resource Library' and two puzzle pieces, one on the left and one on the right, representing a shared resource.


Dynamic Metadata

- Dynamic metadata from usage
- Assistance in resource selection („amazon.com“)
- Quality control

Access and Usage Statistics

Network-wide number of accesses (hits)	890
Number of resources using or importing resource	1 <ul style="list-style-type: none"> • Eukaryotic Gene Control [msu/bio/Gene_Expr/111f03GeneCntrl.sequence]
Number of resources that lead up to this resource in maps	1 <ul style="list-style-type: none"> • Back to the Original Question [msu/bio/Gene_Expr/problems/originalquestion.problem]
Number of resources that follow this resource in maps	1 <ul style="list-style-type: none"> • Eukaryotic vs Prokaryotic Gene Expression II [msu/bio/Gene_Expr/problems/eukvsprokII.problem]
Network-wide number of courses using resource	3 <ul style="list-style-type: none"> • LBS 145 - Spring 2004 • ZOL 341 - Fall 2003 • BS 111 - Fall 2003

Assessment Statistical Data

Total number of students who have worked on this problem	291
Average number of tries till solved	1.37
Degree of difficulty	 (0.36)

Recent Developments

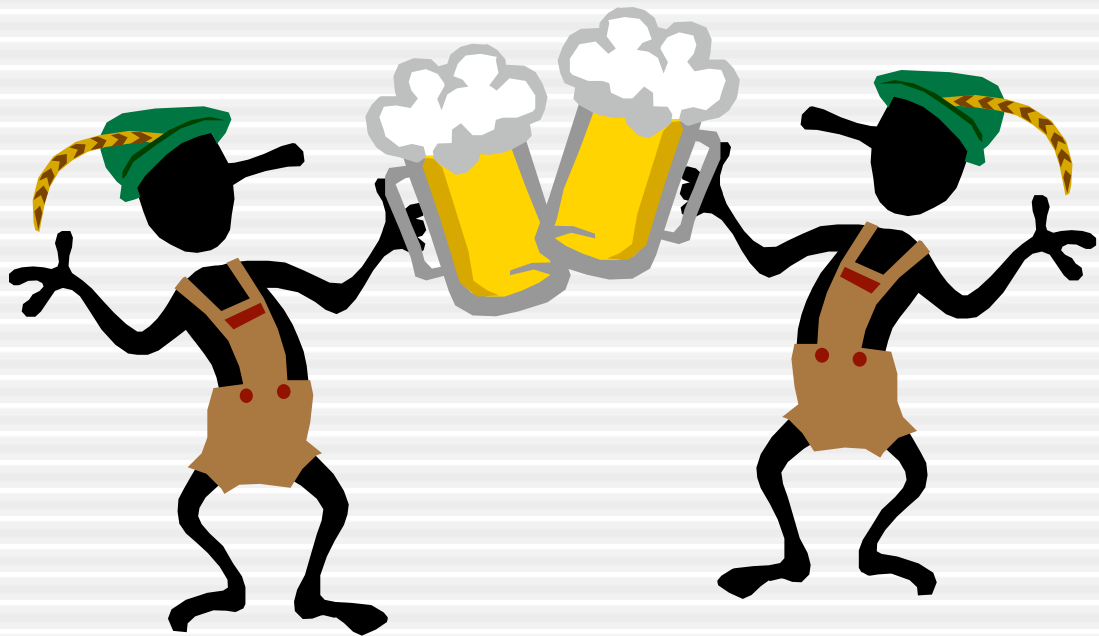
End of NSF Grant

- NSF Grant “An Investigation of a Model for Online Resource Creation and Sharing in Educational Settings” ended in August 2006
- \$2.1M over five years plus one year no-cost extension
- Final report submitted and approved



Free!

- Remember:
 - Free speech
 - Free beer
 - Free ride?



Free Ride?

- Free beer ⇒ hangover
- Free software: you still have to support it
 - Hardware (least of the cost)
 - User support
 - Training
 - Maintenance
- ~~Free Ride~~



No Free Ride

- Growing consensus among CIOs of larger institutions: total cost of ownership of open-source systems on an enterprise level equal to commercial systems
- Admittedly: open-source much better aligned with philosophy of universities



Consortia

- Commercial systems: traditional vendor supports software
- Open-source: best served by a consortium of universities:
 - Broader commitment
 - Distributed cost
 - No “single point of failure”
- With that in place, open-source can be more stable than commercial systems
- Example: folding of WebCT

Academic Consortium

- Founding members:
Michigan State University
and University of Illinois at
Urbana-Champaign
- Associate Member: Simon
Fraser University
- Total commitments of
\$2.15M over the next five
years



MICHIGAN STATE
UNIVERSITY



SIMON
FRASER
UNIVERSITY

Board

- Consortium Board:
 - Determines development priorities
 - Decides on cluster membership
 - Decides on policy questions
 - Evaluates membership contributions
 - Represents the network
 - Technical director reports to it

You can be a member, too

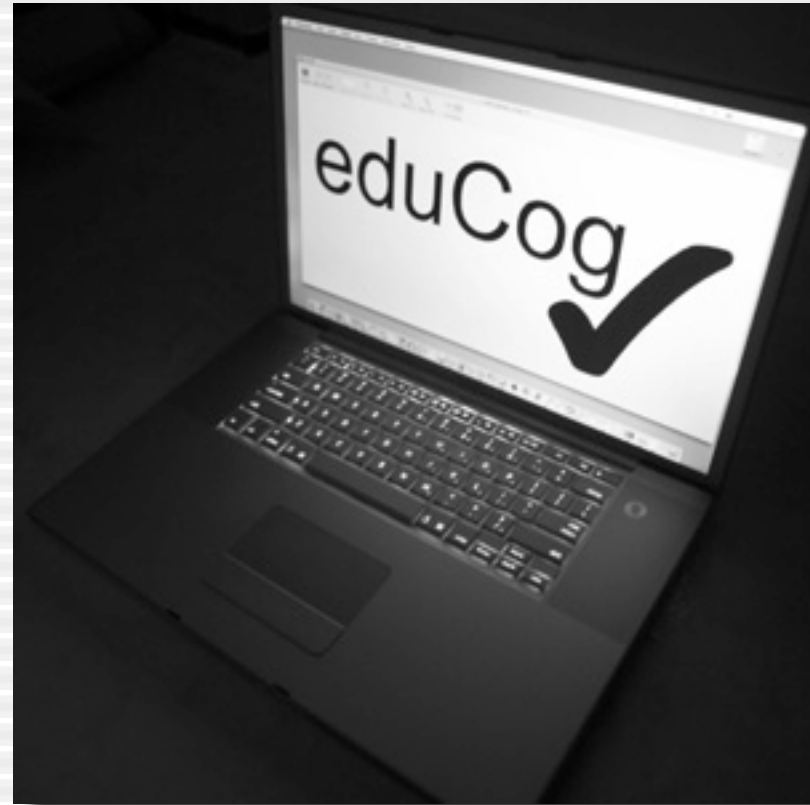
- Core Member:
 - \$200k/year for 5 years
 - at least one fulltime programmer
 - 4 votes on board
- Sustaining Member:
 - \$125k/year for 5 years
 - 2 votes on board
- Associate Member
 - \$50k/year for 3 years
 - 1 vote on board
- Money does not need to leave your campus!

Commercial Spin-Off

- Can you make money with free beer?
- See Redhat Enterprise model
- Provide:
 - Installation and integration services
 - Coding and hosting of problems for publishers
 - Hosting of LON-CAPA for institutions that are unable or unwilling to host their own installation.

Commercial Spin-Off

- eduCog, LLC
- Founded 2005
- Hosting LON-CAPA for
 - 2 Universities
 - 32 Schools
 - 6 Publishing Companies
- Makes a profit already if you neglect the time we pour into it ...



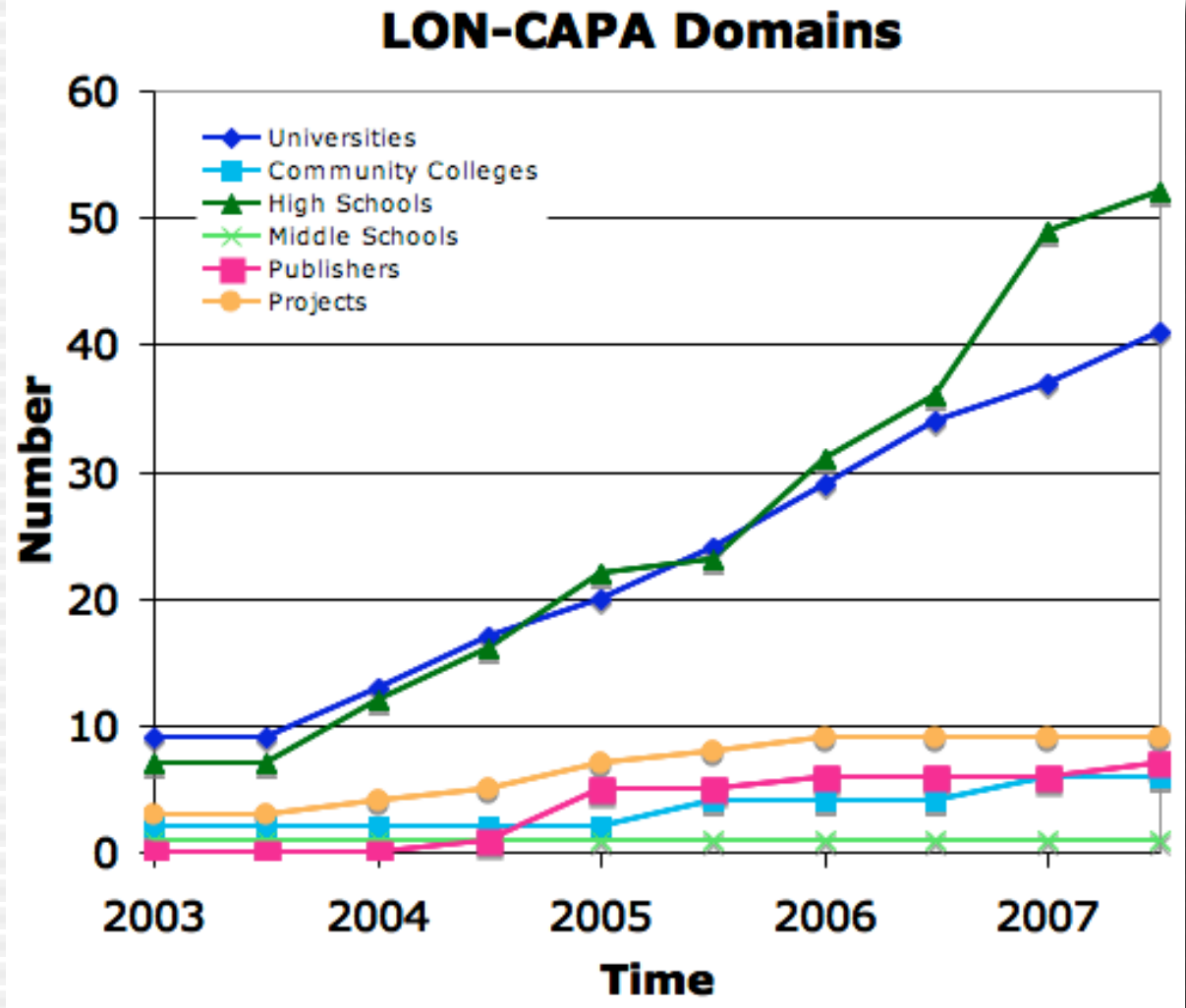
In Other News

- BlackBoard was granted far-reaching patent on course management functionality
- Almost immediately turned around to sue Desire2Learn
- BlackBoard CEO made binding commitment not to sue open-source projects
- Explicitly included LON-CAPA
- Patent challenged in court, very likely will come out with severely reduced claims
- So, life is good?
- BlackBoard also bought WebCT
- Disturbing development for commercial systems
- Maybe life is good for us.



User Institutions

- Increasing number of institutions
- Unexpected growths at K-12 schools
- Linear!
- Exponential?
- Couldn't handle at the moment
- Working on it behind scenes



Release 2.2

- August 2006
- Focus: Additional functionality

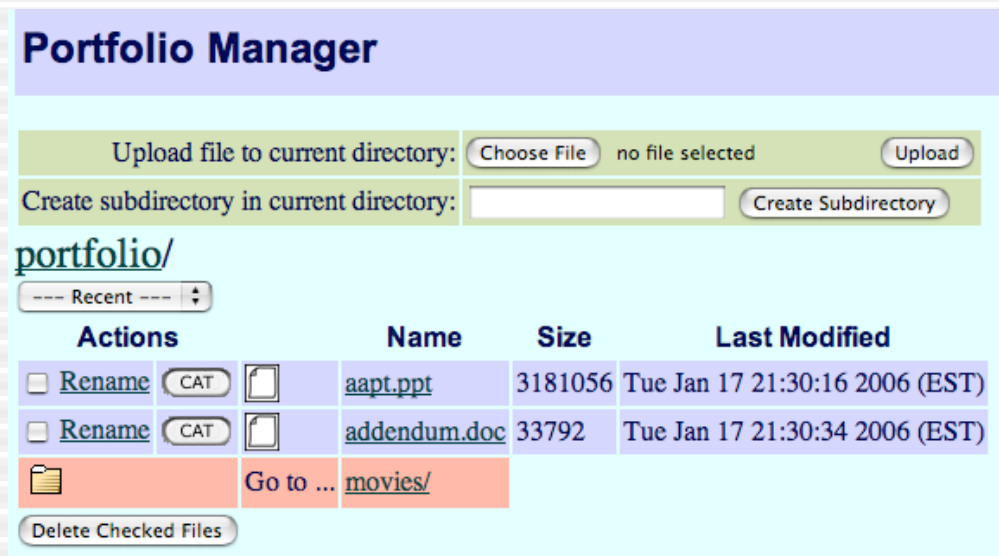
Amazing!

2.2: Single-Sign-On

- LON-CAPA works with Sentinel Single-Sign-On at MSU
- CAS at Florida State
- Ohio University working on Shibboleth

2.2: Public Portfolios

- Portfolio files can be accessed outside the system with and without passphrases
- Automatic listing of files






Portfolio Manager

Upload file to current directory: no file selected

Create subdirectory in current directory:

[portfolio/](#)

--- Recent --- ▾

Actions	Name	Size	Last Modified
<input type="checkbox"/> Rename <input type="button" value="CAT"/> 	aapt.ppt	3181056	Tue Jan 17 21:30:16 2006 (EST)
<input type="checkbox"/> Rename <input type="button" value="CAT"/> 	addendum.doc	33792	Tue Jan 17 21:30:34 2006 (EST)
 <input type="button" value="Go to ..."/>	movies/		

2.2: RSS and Calendaring

- Offering blogs in RSS format
- For course announcements and private blogs
- Private calendar can be downloaded in iCal format

2.2: Content Assembly

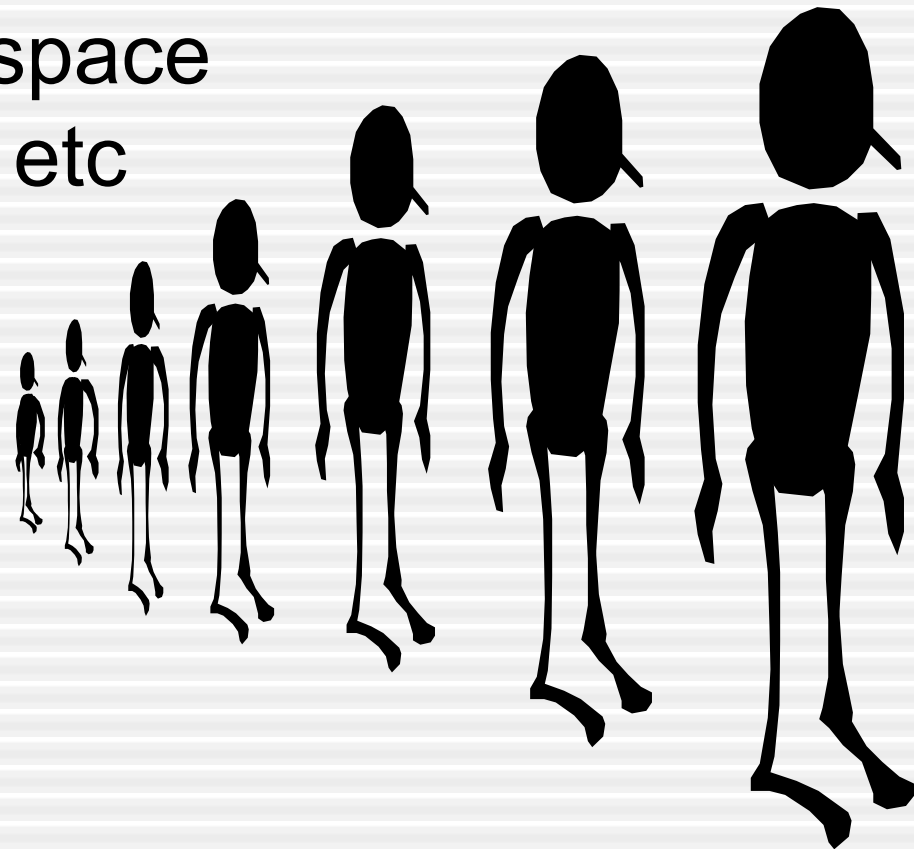
- Direct jump from Search into Browse
- IMS import of WebCT 4 Vista

2.2: Assessment

- Problems can be switched into “practice mode,” so students can do them over and over with different randomizations.
- PARM logs

2.2: Groups

- Groups in addition and independent of sections
- Shared portfolio space and discussions, etc



Release 2.3

- December 2006
- Focus: Additional functionality

Great!

2.3: New functionality

- Users can reset internal passwords
- Actions in DOCS are logged
- PARM and DOCS logs can be searched
- Allowing . and - in usernames

2.3: OR

- Numerical and formula response problems can have more than one correct answer
- Numerical and formula response allow for unordered entry of multiple answers (compared to ordered for vector input)

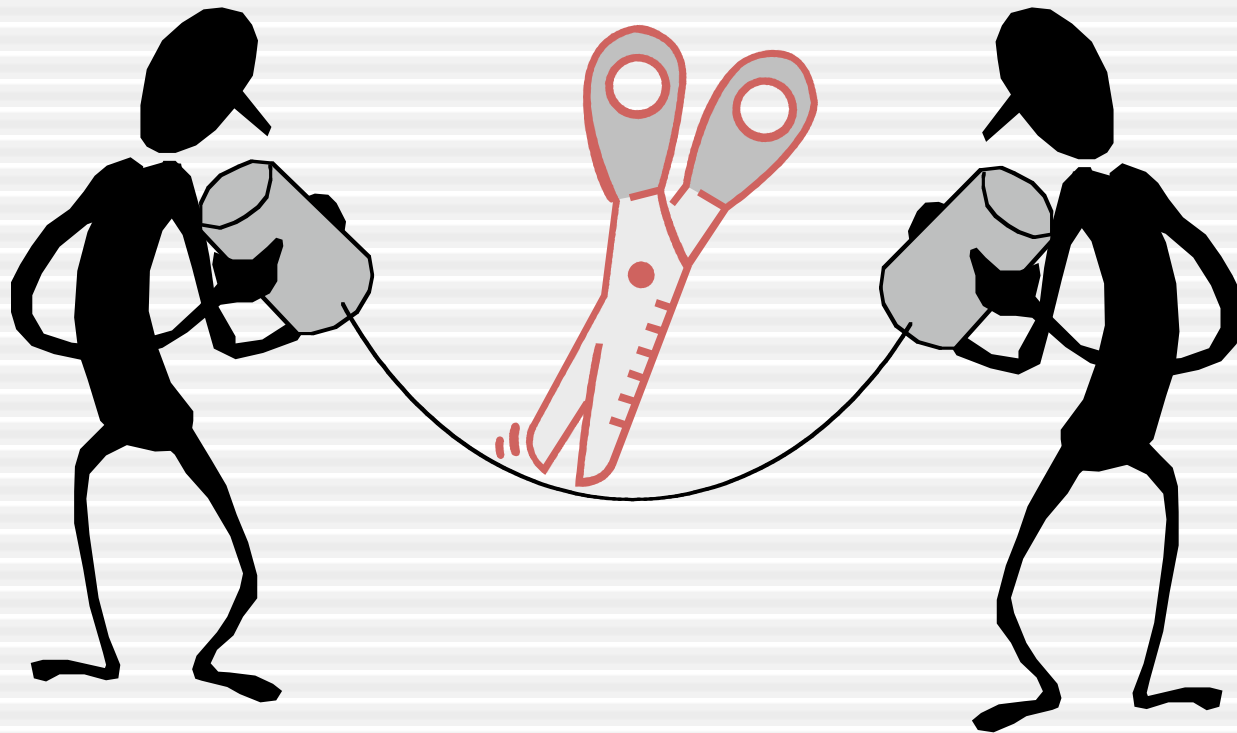
2.3: Podcasting

- Support for podcasting (“blogs with attachments”)



2.3: Communication

- Communication blocking during exams/tests more complete



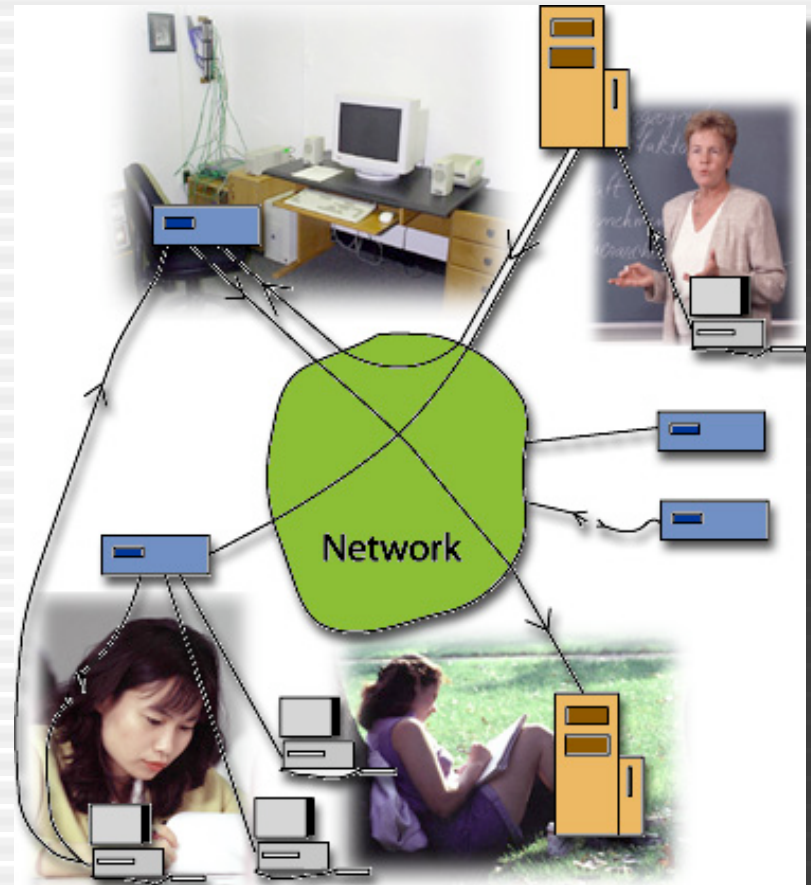
Release 2.3.99.x

- Now
- Release candidate for 2.4, to come out this month
- Focus: Additional functionality and scalability

New and improved!

2.3.99.x: Hosts

- Scalability:
 - Improved management of host tables
 - Easier to add and remove machines from cluster



2.3.99.x: Math Functionality

- Integration of symbolic math system
Maxima

Give an example of a function

- which is orthogonal to $6 \cdot \cos(7 \cdot x) - 2 \cdot \sin(2 \cdot x)$ with respect to the scalar product

$$\langle g | h \rangle = \frac{1}{\pi} \int_{-\pi}^{\pi} dx g(x) \cdot h(x)$$

- whose norm is 1.

The function you have provided does not have a norm of one.

Incorrect. Tries 1

How many solutions does this have?



2.3.99.x: Icons

- Interface can be switched to use icons



Usability and Accessibility

- Carried out:
 - Formal usability study:
 - Students
 - Course Faculty
 - Authors
 - Accessibility study



Publications and Presentations

- Since last conference:
 - 8 colloquia
 - 5 conference presentations
 - 2 peer-reviewed publications in *AJP* and *PhysRev ST-PER*
 - 2 non-peer-reviewed publications

New Grant

- EUR 200,000 (approx. \$265,000) from the German state of Lower Saxony for the further development of LON-CAPA mathematics functionality and content
- Collaboration between the universities of applied science Braunschweig/Wolfenbüttel, Emden, Hannover, and Wilhelmshaven, with the LON-CAPA group

Acknowledgements and Website

- Support provided by
 - National Science Foundation
 - Michigan State University
 - The Alfred P. Sloan Foundation
 - The Andrew W. Mellon Foundation
 - Our partner universities

Visit us at <http://www.lon-capa.org/>